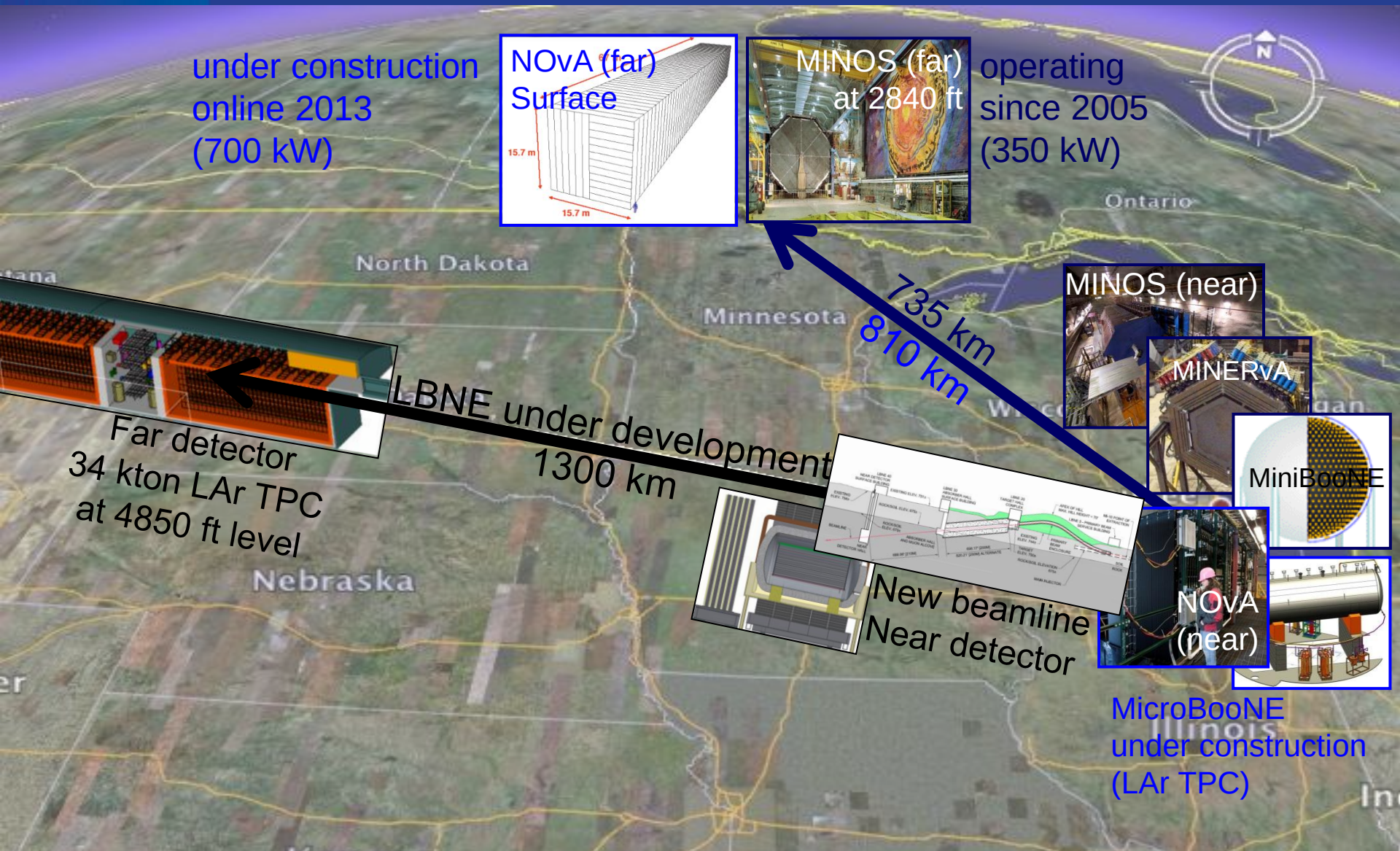
LBNE Reconfiguration: Status and Prospects

Young-Kee Kim

PAC meeting, June 20, 2012



LBNE Science

1. Long Baseline Neutrino Oscillation Physics
   - CP violation
   - Mass hierarchy
   - Precision measurements: θ_{13}, θ_{23}, Δm^2_{32}
   - New neutrino-like particles? new, non-Standard-Model interactions? Other surprises in the neutrino sector?
2. Non-accelerator physics
   - Proton Decay
   - Supernovae burst neutrinos
   - Atmospheric neutrino physics

Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

March 19, 2012

Received on March 26

Dr. Pier Oddone
Director
Fermilab
Wilson and Kirks Road
Batavia, IL 60510-5011

Dear Pier,

Thank you for your recent presentation on the status and plans for the Long Baseline Neutrino Experiment (LBNE). The project team and the scientific collaboration have done an excellent job responding to our requests to assess the technology choices and refine the cost estimates for LBNE. We believe that the conceptual design is well advanced and the remaining technical issues are understood.

The scientific community and the National Academy of Sciences repeatedly have examined and endorsed the case for underground science. We concur with this conclusion, and this has been the motivator for us to determine a path forward as quickly as possible following the decision of the National Science Board to terminate development of the Homestake Mine as a site for underground science.

We have considered both the science opportunities and the cost and schedule estimates for LBNE that you have presented to us. We have done so in the context of planning for the overall Office of Science program as well as current budget projections.

Based on our considerations, we cannot support the LBNE project as it is currently configured. This decision is not a negative judgment about the importance of the science, but rather it is a recognition that the peak cost of the project cannot be accommodated in the current budget climate or that projected for the next decade.

In order to advance this activity on a sustainable path, I would like Fermilab to lead the development of an affordable and phased approach that will enable important science results at each phase. Alternative configurations to LBNE should also be considered. Options that allow us to independently develop the Homestake Mine as a future facility for dark matter experiments should be included in your considerations.

A report outlining options and alternatives is needed as soon as practical to provide input to our strategic plan for the Intensity Frontier program. OHEP will provide additional details on realistic cost and schedule profiles and on the due date for the report.

Thank you,

W. F. Brinkman
Director, Office of Science

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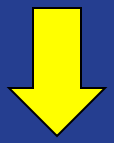


In order to advance this activity on a sustainable path, I would like Fermilab to lead the development of an affordable and phased approach that will enable important science results at each phase. Alternative configurations to LBNE should also be considered.

The alternatives include options that do not require further development of the Homestake site.

Director's Corner

Long-Baseline Neutrino Experiment

We have started a vigorous effort to answer Office of Science Director Bill Brinkman's charge to Fermilab to find a path forward to reach the goals of the Long-Baseline Neutrino Experiment in a phased approach.

Fermilab Director Pier Oddone

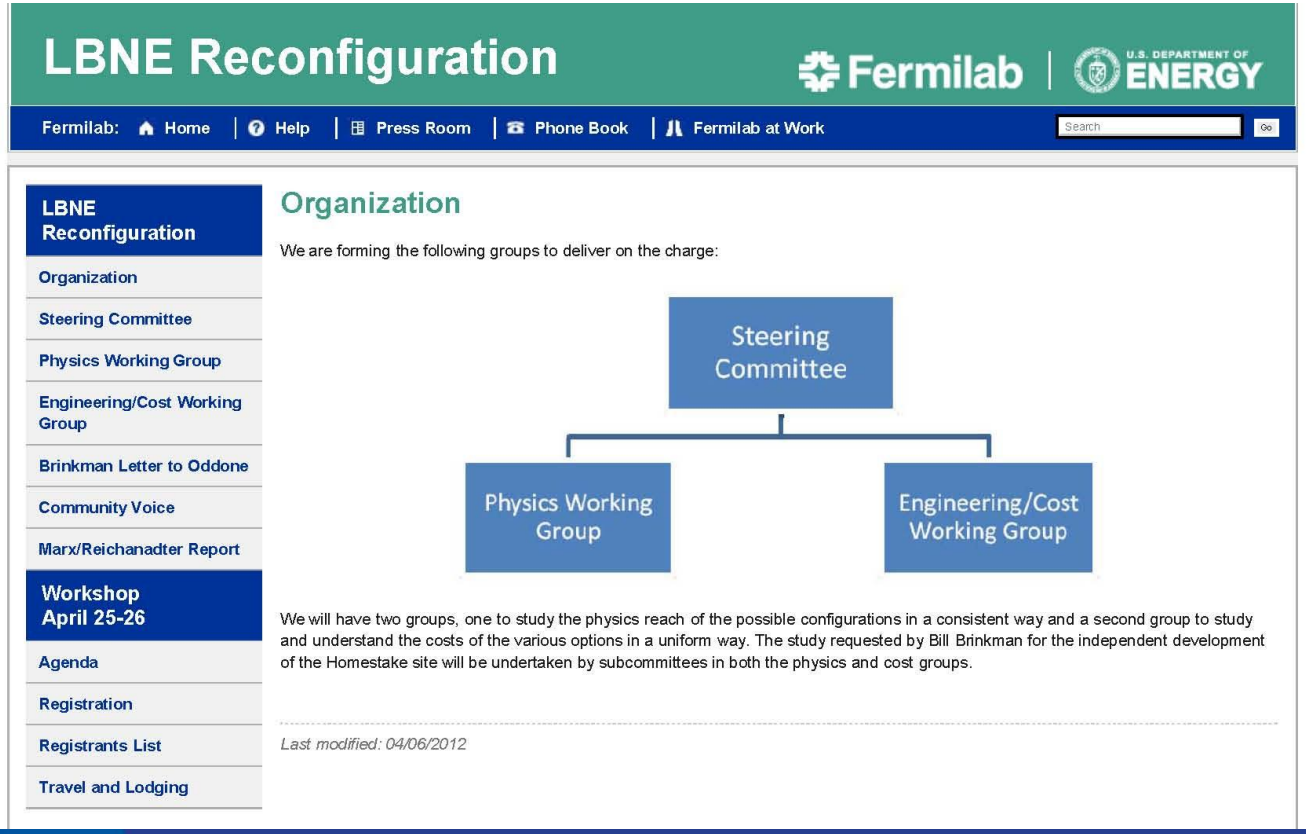
A steering committee led by Deputy Director Young-Kee Kim, with many of the LBNE stakeholders as members, will guide the study. The steering committee will have two working groups: the physics working group, led by Mel Shochet of the University of Chicago, and the engineering/cost working group, led by Mark Reichanadter of SLAC. The steering committee will provide guidance to the working groups and will ultimately write the report for DOE. The physics working group will analyze the physics reach of the various phases and alternatives on a common basis. Similarly, the engineering/cost working group will provide cost estimates and analyze the feasibility of the proposed approaches with the same methodology. These two groups will provide to the steering committee factual input that covers as many aspects of the various options as possible.

To inform the community, discuss the status of the work in progress and seek input, we will hold a workshop on April 25 and 26 that is open to all interested parties.

The time scale for concluding these studies is very short because the results will influence the Congressional budget process for FY13 and the Office of Science planning process for FY14. We plan to have a preliminary report by June 1, which will be vetted by our Physics Advisory Committee and the FRA Board of Directors. A final report will be available on July 1.

Organization of the effort
Open Process

http://www.fnal.gov/directorate/lbne_reconfiguration/index.shtml



Jeff Appel: Scientific Secretary for the Steering Committee and Working Groups

The Steering Committee

Membership	Institution	Comments
Young-Kee Kim (Chair)	Fermilab	Deputy Director, LBNE LOG (Lab Oversight Group) member
James Symons	LBNL	Associate Lab Director, LBNE LOG member
Steve Vigdor	BNL	Associate Lab Director, LBNE LOG member
Bob Svoboda	UC Davis	LBNE co-spokesperson
Kevin Lesko	LBNL	SURF (Sanford Underground Research Facility) head
Gary Feldman	Harvard	NOvA co-spokesperson
Mel Shochet	Chicago	Physics working group chair, Former HEPAP chair
Mark Reichanadter	SLAC	Engineering/Cost working group chair DOE DUSEL review committee co-chair
Charlie Baltay	Yale	P5 chair
Jon Bagger	JHU	Former HEPAP deputy chair
Ann Nelson	UW Seattle	HEPAP member

Ex-officio group

Membership	Institution	Comments
Andy Lankford	UC Irvine	HEPAP chair, DUSEL NRC study chair
Steve Ritz	UC Santa Cruz	PASAG (Particle Astrophysics Scientific Assessment Group) chair, Fermilab PAC member
Jay Marx	Caltech	DOE DUSEL review committee co-chair
Pierre Ramond	U. Florida	DPF chair
Harry Weerts	ANL	DOE Intensity Frontier Workshop co-chair
JoAnne Hewett	SLAC	DOE Intensity Frontier Workshop co-chair
Jim Strait	FNAL	LBNE Project Manager Engineering/Cost working group deputy chair
Pier Oddone	FNAL	Director, Fermilab
Susan Seestrom	LANL	LBNE LOG (Lab Oversight Group) member

Working Groups

Physics Working Group	Engineering / Cost Working Group
Mel Shochet, U.Chicago (chair) Mary Bishai, BNL Ed Blucher, UChicago Steve Brice, FNAL Milind Diwan, BNL Bonnie Fleming, Yale Gil Gilchriese, LBNL Bill Marciano, BNL Mark Messier, Indiana Stephen Parke, FNAL Gina Rameika, FNAL Kate Scholberg, Duke Jenny Thomas, UCL Charlie Young, SLAC Sam Zeller, FNAL	Mark Reichanadter, SLAC (chair) Jim Strait, FNAL (deputy chair) Bruce Baller, FNAL Mike Headley, SURF Marvin Marshak, U. Minnesota Chris Mauger, LANL Elaine McCluskey, FNAL Vaia Papadimitriou, FNAL Bob O'Sullivan, FNAL Jeff Sims, ANL Additional invitation to Tracy Lundin (FNAL) Jeff Dolph (BNL) Jim Stewart (BNL) Joel Sefcovic (FNAL)

LBNE Reconfiguration Workshop

25-26 April 2012 *Fermi National Accelerator Laboratory*
US/Central timezone

Support

We have started a vigorous effort to answer Office of Science Director Bill Brinkman's charge to Fermilab to find a path forward to reach the goals of the Long-Baseline Neutrino Experiment in a phased approach. A steering committee led by Deputy Director Young-Kee Kim, with many of the LBNE stakeholders as members, will guide the study. The steering committee will have two working groups: the physics working group, led by Mel Shochet of the University of Chicago, and the engineering/cost working group, led by Mark Reichanadter of SLAC. The Committee is asked to deliver a preliminary report by June 1 and a final report by July 1. Detailed information can be found at http://www.fnal.gov/directorate/lbne_reconfiguration/

To inform the community, discuss the status of the work in progress and seek input, we will hold a workshop on April 25 and 26 that is open to all interested parties. ReadyTalk will be available for remote participation. Agenda includes:

* Initial studies done by working groups
* Community voice from LBNE collaboration (April 26)
* Community voice on NuMI options (April 25)
* Community voice: open mics (60' on April 25 and 60' on April 26)
* Discussion forum towards building concensus

If you would like to sign up for a time slot for the open mike sessions (up to 2 slides / 5' each), please send an email to Jon Bagger, Steve Vigdor and Mary-Ellyn McCollum (bagger@jhu.edu, vigdor@bnl.gov, mccollum@fnal.gov).

"Community voice from LBNE collaboration" and "Community voice on NuMI options" are organized by LBNE co-spokespersons and MINOS/NOvA co-spokespersons, respectively.

Dates: from 25 April 2012 03:05 to 26 April 2012 13:00
Timezone: US/Central
Location: *Fermi National Accelerator Laboratory*
Batavia, Illinois
Room: One West, Wilson Hall
Chairs: Kim, Young-Kee

Workshop (1/2)

April 25 (day 1)

- Plenary session (chair: Bob Wilson)
  - 10:30 am Welcome – Pier Oddone (5')
  - 10:35 am Introduction – Young-Kee Kim (30' + 5')
  - 11:10 am Physics Working Group: Introduction + Summary of Initial Studies – Mel Shochet / Gina Rameika (40'+10')
  - 12:00 pm Lunch (60')
- Plenary session (chair: Brajesh Choudhary)
  - 1:00 pm Engineering / Cost Working Group: Introduction – Mark Reichanadter or Jim Strait (10' + 5')
  - 1:15 pm Beamline including Conventional Facilities: assumptions and cost estimates - Vaia Papadimitriou (30' + 15')
  - 2:00 pm Near Detector including Conventional Facilities: assumptions and cost estimates - Christopher Mauger (15' + 5')
  - 2:20 pm Conventional Faclities for the Far Detector: assumptions and cost estimates - Tracy Lundin (30' + 15')
  - 3:05 pm Far Detector: assumptions and cost estimates – Bruce Baller (25' + 10')
  - 3:40 pm Coffee Break (30')
- Plenary session (chair: Kevin Lesko)
  - 4:10 pm Community voice: moderated discussion focusing on NuMI options (60')
    - This session is organized by MINOS + NOvA co-spokespersons
  - 5:10 pm Community voice: open mikes – up to 2 slides / 5' each (60')
    - If you want to sign up for a time slot, please send an email to Jon Bagger, Steve Vigdor and Mary-Ellyn McCollum (bagger@jhu.edu, vigdor@bnl.gov, mccollum@fnal.gov).
- Reception (6:30 – 8:30 pm) – Wilson Hall 2nd floor South Crossover

Workshop (2/2)

April 26 (day 2)

- Plenary session (chair: Jon Rosner)
  - 8:00 am Neutrino reach – Mary Bishai (30' + 10')
  - 8:40 am Proton decay and cosmic neutrino reach – Kate Scholberg (30' + 10')
  - 9:20 am Community voice: LBNE collaboration (60')
    - This session is organized by LBNE co-spokespersons
  - 10:20 am Coffee Break (30')

- Plenary session (chair: Shekhar Mishra)
  - 10:50 am Community voice: open mikes – up to 2 slides / 5' each (60')
    - If you want to sign up for a time slot, please send an email to Jon Bagger, Steve Vigdor and Mary-Ellyn McCollum (bagger@jhu.edu, vigdor@bnl.gov, mccollum@fnal.gov).
  - 11:50 am Community voice: moderated discussion – moderator: Charlie Baltay (40')
  - 12:30 pm Wrap-up (15') – Young-Kee Kim

LBNE Reconfiguration: Workshop

More than 200 participants

Process through the Interim Report: Summary

- Open process: http://www.fnal.gov/directorate/lbne_reconfiguration/
- March 26: Received Brinkman's letter
- April 3: Steering Committee + 2 WGs formed
- Steering Committee
  - 9 conference call meetings
  - 2 face-to-face meetings (April 26, May 22-23) at Fermilab
- Working Groups: Conference call meetings
- Engaging the community as much as possible
  - Messages to DPF members and Fermilab Users, Fermilab Today article, …
  - Workshop on April 25-26 at Fermilab
  - Letters from the community: discussed at SC meetings
- Interim Report: June 5, 2012

Options considered but rejected

- New beamline + baseline (~1,300 km or longer) with surface detector locations other than Homestake
- Existing NuMI beamline + baseline (> 810 km)
- Underground detector only (no beam)
- ……

Interim Conclusions

- To achieve all of the fundamental science goals of LBNE, a reconfigured LBNE would need a very long baseline (>1,000 km from accelerator to detector) and a large detector deep underground. However, it is not possible to meet both of these requirements in a first phase of the experiment within the budget guideline of approximately $700M – $800M, including contingency and escalation.

- The committee assessed various options that meet some of the requirements, and identified three viable options for the first phase of a long-baseline experiment that have the potential to accomplish important science at realizable cost.

Interim Conclusions

- These options are (not priority ordered):
  - Using the existing NuMI beamline in the low energy configuration with a 30 kton LAr-TPC surface detector 14 mrad off-axis at Ash River in Minnesota, 810 km from Fermilab.
  - Using the existing NuMI beamline in the low energy configuration with a 15 kton LAr-TPC underground (at the 2,340 ft level) detector on-axis at the Soudan Lab in Minnesota, 735 km from Fermilab.
  - Constructing a new low energy LBNE beamline with a 10 kton LAr-TPC surface detector on-axis at Homestake in South Dakota, 1,300 km from Fermilab.
- The committee looked at possibilities of projects with significantly lower costs and concluded that the science reach for such projects becomes marginal.

Interim Conclusions

Summary: 30 kton at Ash River (surface)

Pros	• Best Phase 1 CP-violation sensitivity in combination with NOvA and T2K results for the current value of θ_{13}. The sensitivity would be enhanced if the mass ordering were known from other experiments. • Excellent (3σ) mass ordering reach in nearly half of the δ_{CP} range.

Cons	• Narrow-band beam does not allow measurement of oscillatory signature.
	• Shorter baseline risks fundamental ambiguities in interpreting results.
	• Sensitivity decreases if θ_{13} is smaller than the current experimental value.
	• Cosmic ray backgrounds: impact and mitigation need to be determined.
	• Only accelerator-based physics.
	• Limited Phase 2 path:
	  ○ Beam limited to 1.1 MW (Project X Stage 1).
	  ○ Phase 2 could be a 15-20 kton underground (2,340 ft) detector at Soudan.

Interim Conclusions

Summary: 15 kton at Soudan (2340 ft)

Pros	• Broadest Phase 1 physics program:
	  ○ Accelerator-based physics including good (2σ) mass ordering and good CP-violation reach in half of the δ_{CP} range. CP-violation reach would be enhanced if the mass ordering were known from other experiments.
	  ○ Non-accelerator physics including proton decay, atmospheric neutrinos, and supernovae neutrinos.
	• Cosmic ray background risks mitigated by underground location.

Cons	• Mismatch between beam spectrum and shorter baseline does not allow full measurement of oscillatory signature.
	• Shorter baseline risks fundamental ambiguities in interpreting results. This risk is greater than for the Ash River option.
	• Sensitivity decreases if θ_{13} is smaller than the current experimental value.
	• Limited Phase 2 path:
	  ○ Beam limited to 1.1 MW (Project X Stage 1).
	  ○ Phase 2 could be a 30 kton surface detector at Ash River or an additional 25-30 kton underground (2,340 ft) detector at Soudan.

Interim Conclusions

Summary: 10 kton at Homestake (surface)

Pros	• Excellent (3σ) mass ordering reach in the full δ_{CP} range. • Good CP violation reach: not dependent on *a priori* knowledge of the mass ordering. • Longer baseline and broad-band beam allow explicit reconstruction of oscillations in the energy spectrum: self-consistent standard neutrino measurements; best sensitivity to Standard Model tests and non-standard neutrino physics. • Clear Phase 2 path: a 20 – 25 kton underground (4850 ft) detector at the Homestake mine. This covers the full capability of the original LBNE physics program. • Takes full advantage of Project X beam power increases.
Cons	• Cosmic ray backgrounds: impact and mitigation need to be determined. • Only accelerator-based physics. Proton decay, supernova neutrino and atmospheric neutrino research are delayed to Phase 2. • ~10% more expensive than the other two options: cost evaluations and value engineering exercises in progress.

Interim Conclusions

While each of these first-phase options is more sensitive than the others in some particular physics domain, the Steering Committee in its discussions strongly favored the option to build a new beamline to Homestake with an initial 10 kton LAr-TPC detector on the surface.

The physics reach of this first phase is very strong; more over this option is seen by the Steering Committee as a start of a long-term world-leading program that would achieve the full goals of LBNE in time and allow probing the Standard Model most incisively beyond its current state. Ultimately this option would exploit the full power provided by Project X. At the present level of cost estimation, it appears that this preferred option may be ~10% more expensive than the other two options, but cost evaluations and value engineering exercises are continuing.

Interim Conclusions

In the next few months the LBNE collaboration and external experts will be studying the operation of LAr-TPCs on the surface to verify that the cosmic ray backgrounds are manageable. The operation on the surface may require shorter drift times than required for underground operations and the localization of the event in the TPC coincident with the ten microsecond-long beam from Fermilab.

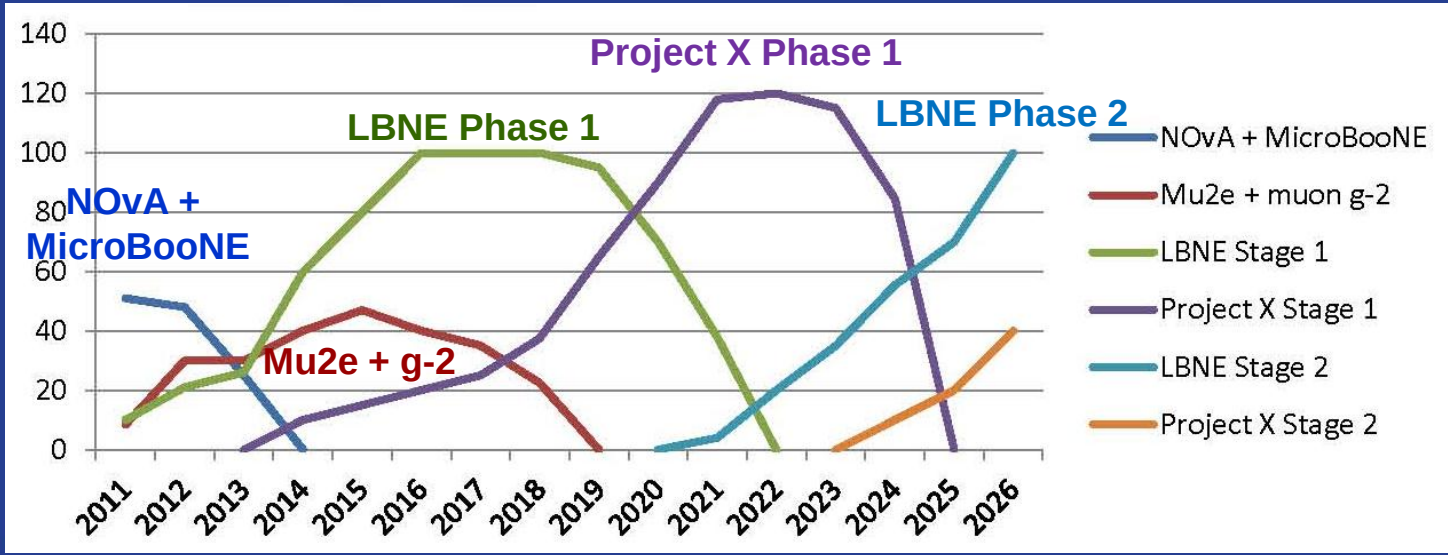
The Phase 1 experiment will use the existing detectors (MINOS near detector, MINERvA, and NOvA near detector) as near detectors for the two NuMI options, and use muon detectors to monitor the beam for the Homestake option. The Physics working group is currently studying the impact of near detectors on the physics reach.

Interim Conclusions

Although the preferred option has the required very long baseline, its major limitation of the preferred option is that the underground physics program including proton decay and supernova collapse cannot start until later phases of the project. Placing a 10 kton detector underground instead of the surface in the first phase would allow such a start, and increase the cost by about $135M.

A potential R&D + construction timeline

Phases in Project X can be intercalated with phases of LBNE



Budget profiles for a potential path for LBNE and Project X staging, assuming $700M for each LBNE or Project X stage. The total peak cost not to exceed $160M. Contributions from other funding agencies (U.S. or abroad) could lower the DOE cost.

Since the Interim Report

- Funding agencies
  - June 6: Briefing to DOE
  - June 18: Briefing to NSF
- Input from Fermilab advisory bodies
  - June 14-15: FRA Board Meeting
  - June 19-23: PAC Meeting
- Feedback from the community
  - Messages sent to DPF chairs, Fermilab Users' executive committee, DOE intensity frontier workshop conveners / working group conveners to receive feedback from the community
  - DPF is setting up a webpage where comments can be sent / posted.
  - DPF newsletter article and Fermilab Today article in preparation

Since the Interim Report

- Communication with non-U.S. community
  - Presentations at conferences (a little before the interim report)
    - Workshop at Gran Sasso
    - European Neutrino town meeting
    - Neutrino 2012
  - Communicated with leaders in India, Canada, Italy, CERN, KEK, UK, …
  - Scheduled to have a number of meetings at ICHEP
  - A letter to the European Strategy Group in preparation
- Any suggestions from the PAC?